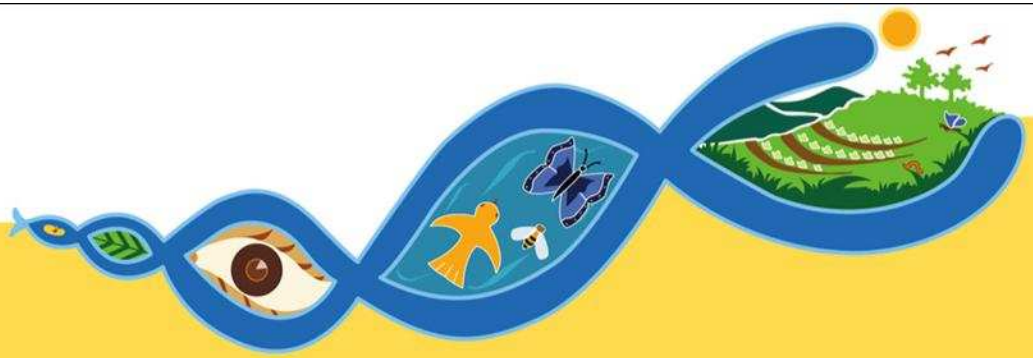
cirad
AGRICULTURAL RESEARCH
FOR DEVELOPMENT



THE PEST AND DISEASE CONTROL FUNCTION OF AGROBIODIVERSITY AT THE FIELD SCALE

A. Ratnadass, J. Avelino, P. Fernandes

R. Habib & P. Letourmy

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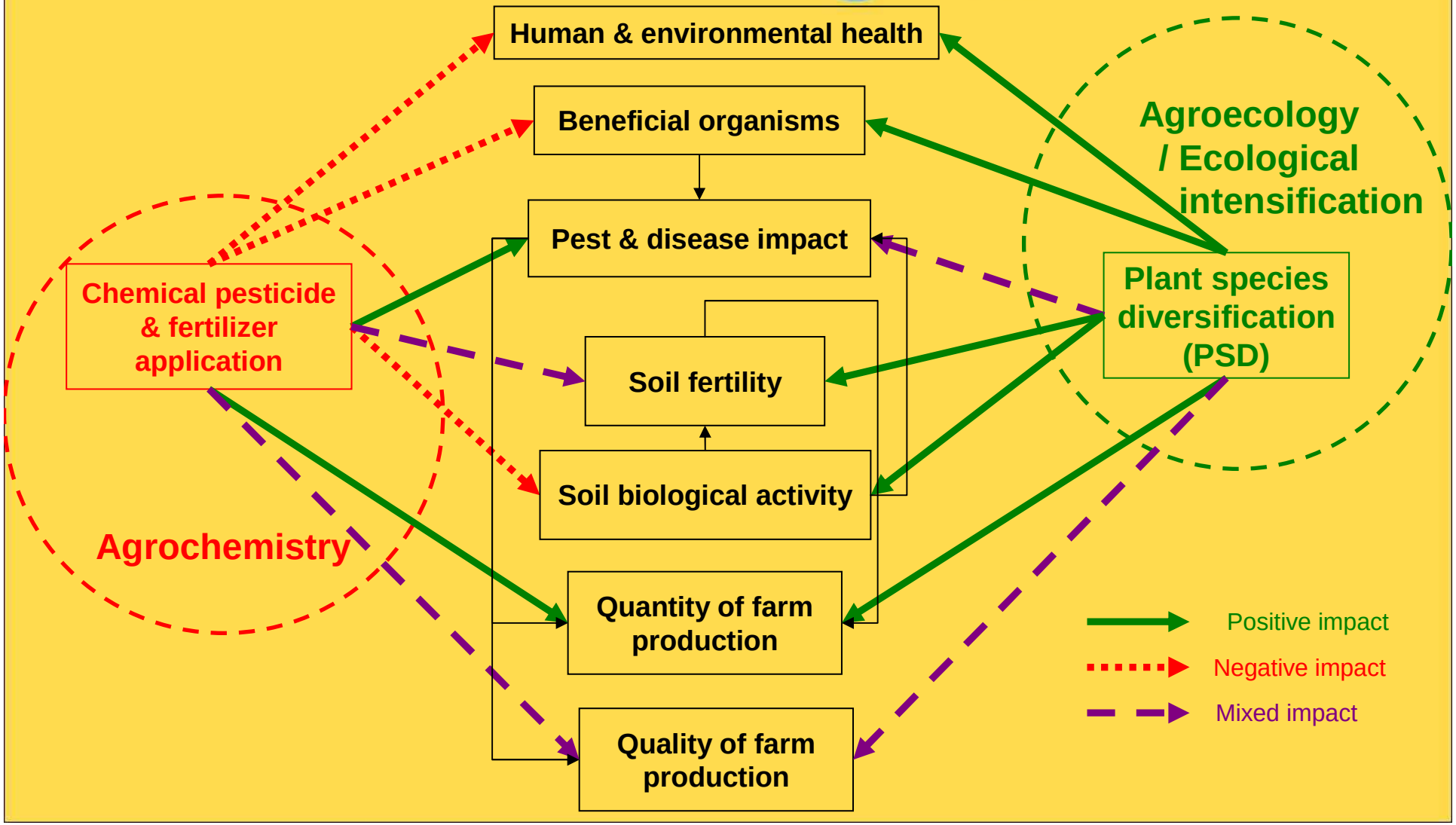
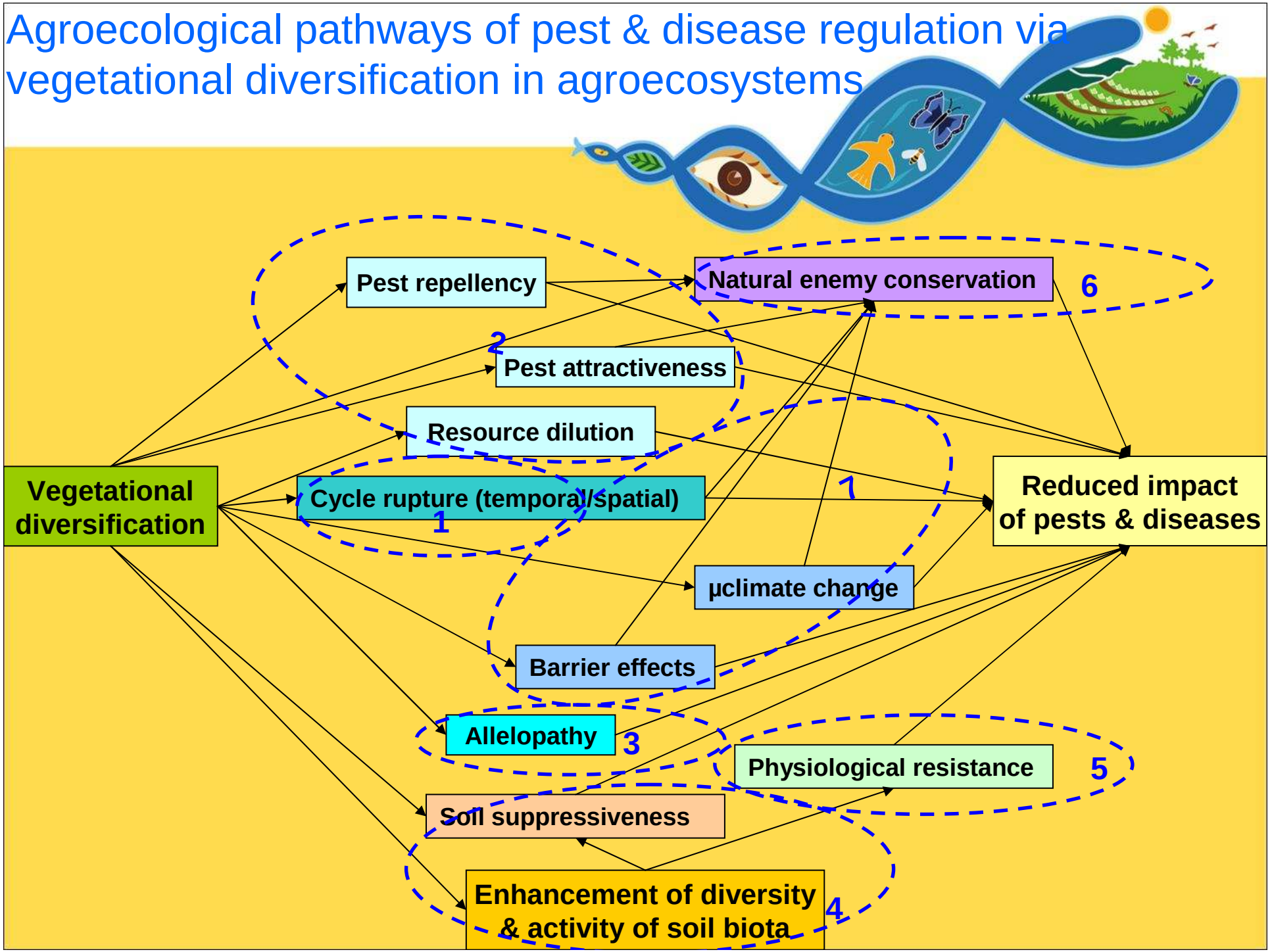
Background: Challenges facing tropical agriculture

- food insecurity and low-income in low-input traditional agrosystems
- pesticide-induced adverse impacts on human health and the environment in intensive systems
- export restrictions due to strict regulations imposed by importing countries

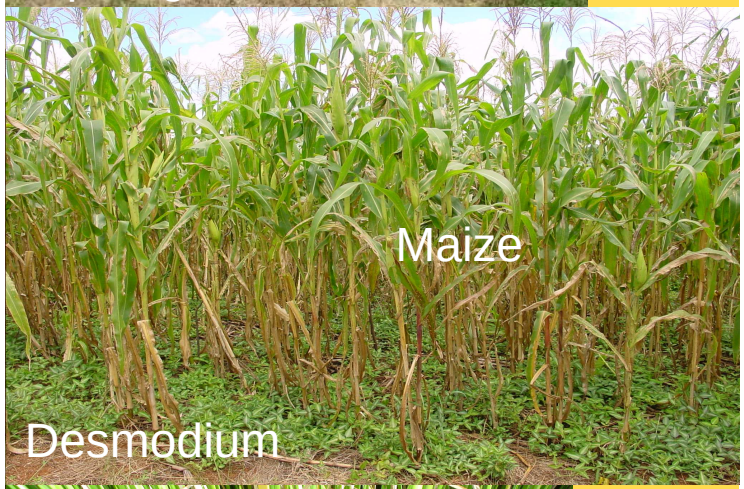
Plant species diversification as the main pillar of ecological intensification

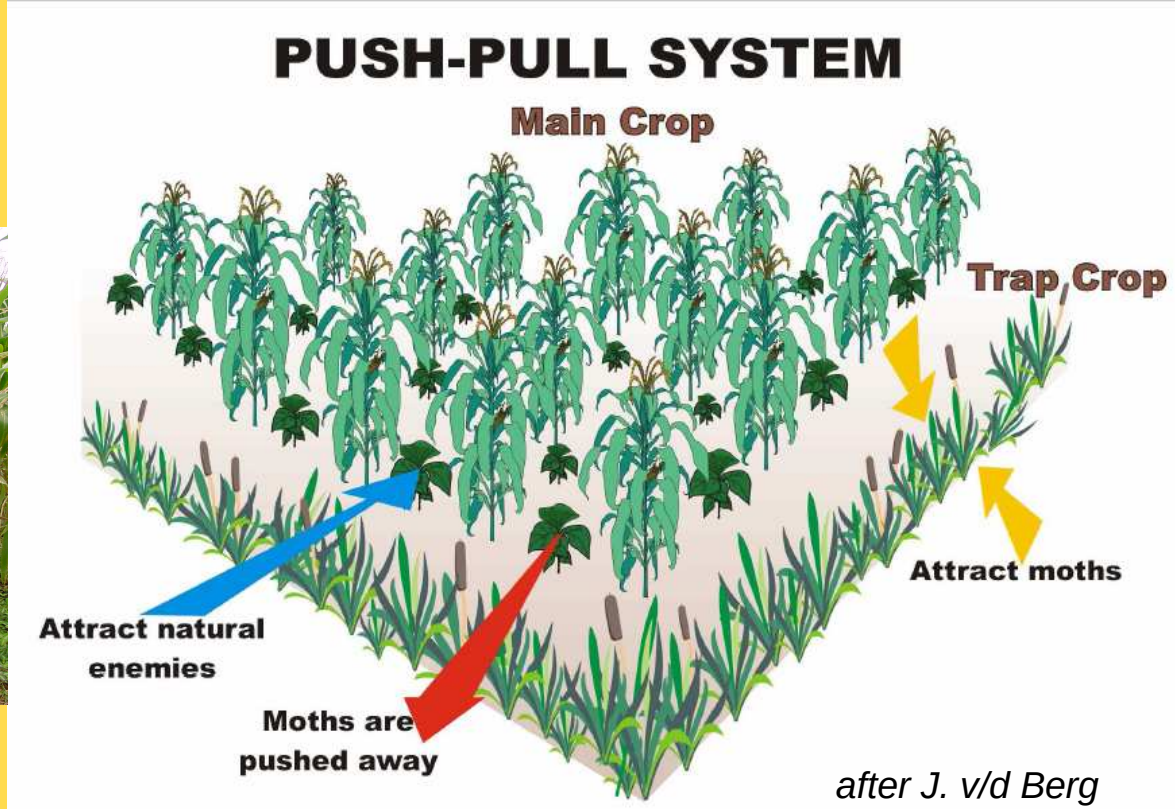


Agroecological pathways of pest & disease regulation via vegetational diversification in agroecosystems



Tropical example : the « push-pull » system in Eastern & Southern Africa





after J. v/d Berg

Examples of application of these principles at Cirad at the soil and field levels

- Influence of soil organic matter quantity and quality on the status of Scarab beetles associated with upland rice in Madagascar
- Study of the various host plants of sorghum panicle-feeding bugs in Mali and Niger
- Evaluation of trap crops for management of Tomato fruit worm on Okra in Niger

Influence of soil organic matter quantity and quality on the status of Scarab beetles associated with upland rice in Madagascar

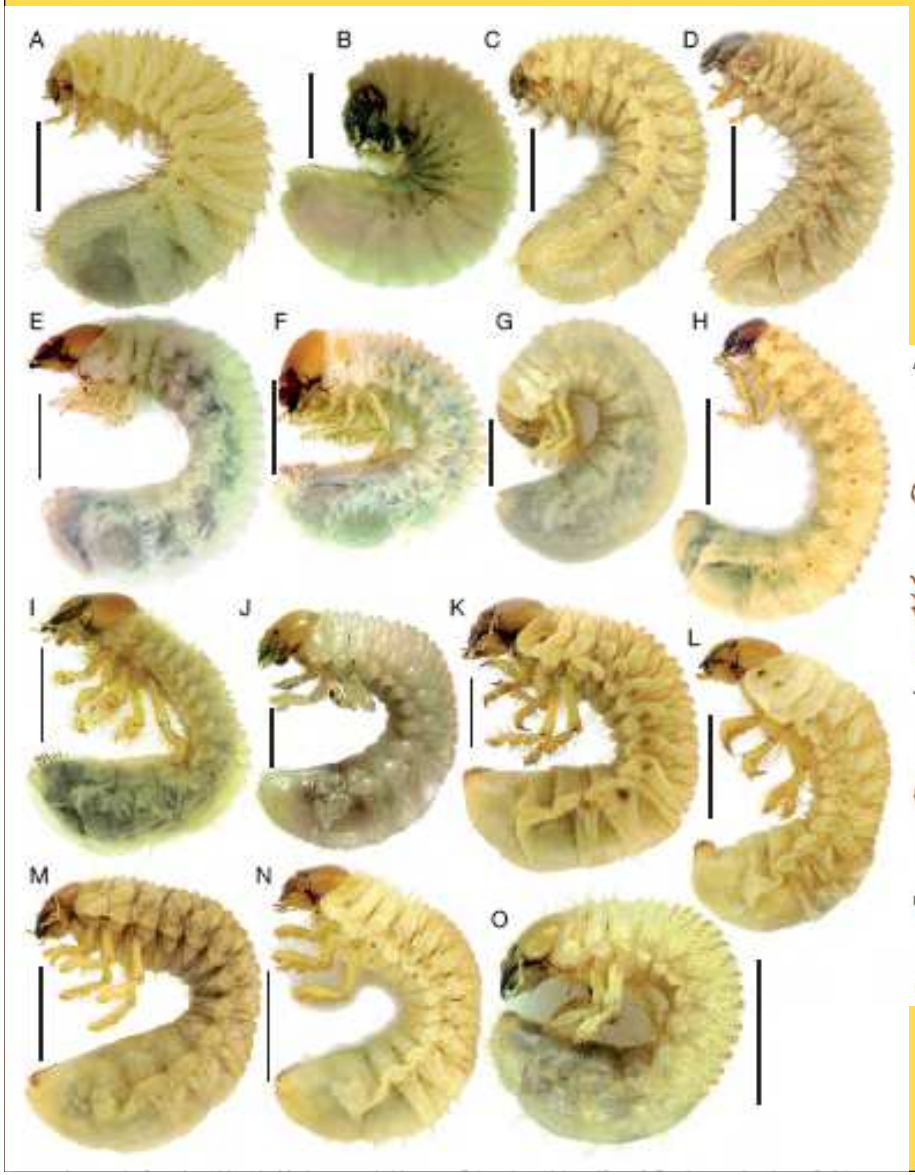
- In Madagascar, growing demand for rice and resulting increased pressure on inundated lands has favoured the cultivation of upland rice on hill slopes, particularly in the high & medium altitude regions of the island
- If conventional tillage is used, this type of agriculture cannot meet the objectives of both sustainability and of high yields, due to high erosion, and to attacks by white grubs & black beetles, particularly in the medium-elevation region of Lake Alaotra
- Direct seeding, mulch-based cropping (DMC) systems have opened new prospects for upland rice, reducing erosion, and after a few years, attacks by white grubs & black beetles in the Central Highlands of Vakinankaratra

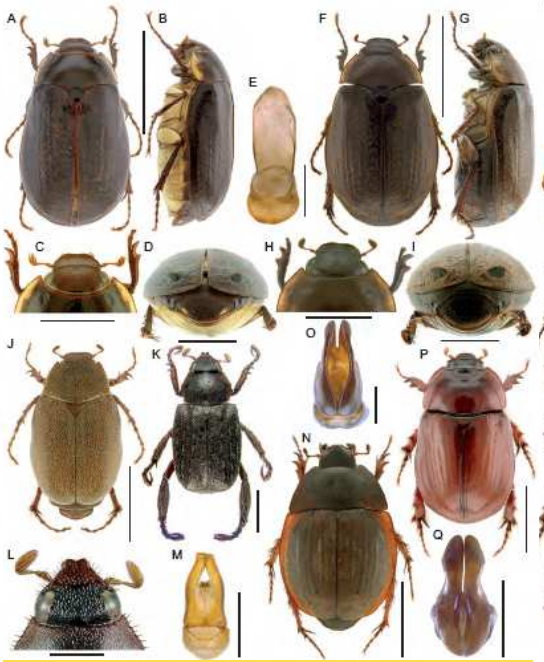
Example of reduction of black beetle impact on upland rice production in Central Highlands of Vakinankaratra (Madagascar)

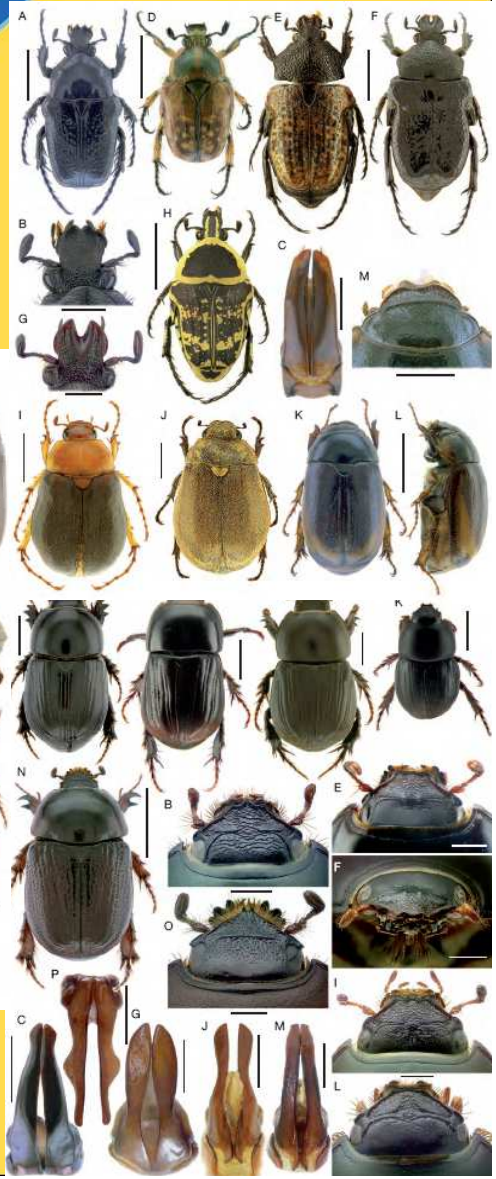
Rice yield (cv FOFIFA 161) in 2002-03 (t/ha)
(/annual rice//soybean rotations, conducted since 1998 under DMC on crop residues and under conventional tillage)

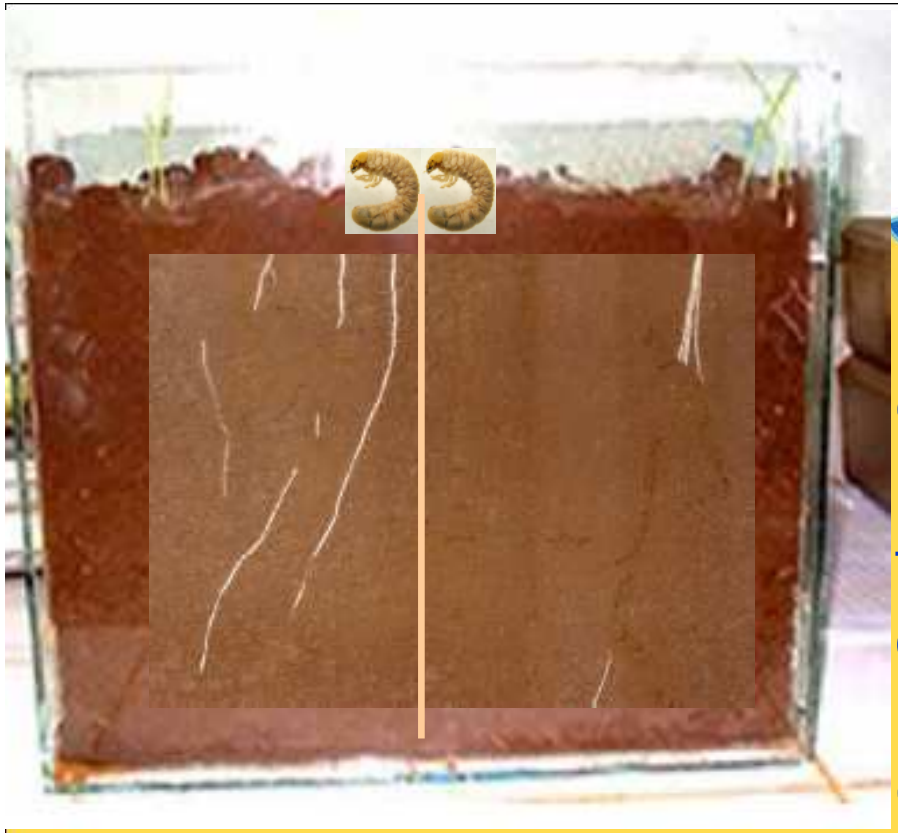
	DMC with Imidacloprid seed-dressing	DMC without seed-dressing	Conventional tillage with Imidacloprid seed-dressing	Conventional tillage without seed-dressing
Andranomanelatra	**3,2**	**2,6**	**2,8**	**1,7**
Ibity	**3,7**	**2,4**	**2,3**	**1,7**

RANDRIAMANANTSOA, R., ABERLENC, H.P., RALISOA, O.B., RATNADASS, A. & VERCAMBRE, B. 2010. Les larves des Scarabaeoidea (Insecta, Coleoptera) en riziculture pluviale des régions de haute et moyenne altitudes du Centre de Madagascar. Zoosystema 32:19-72.



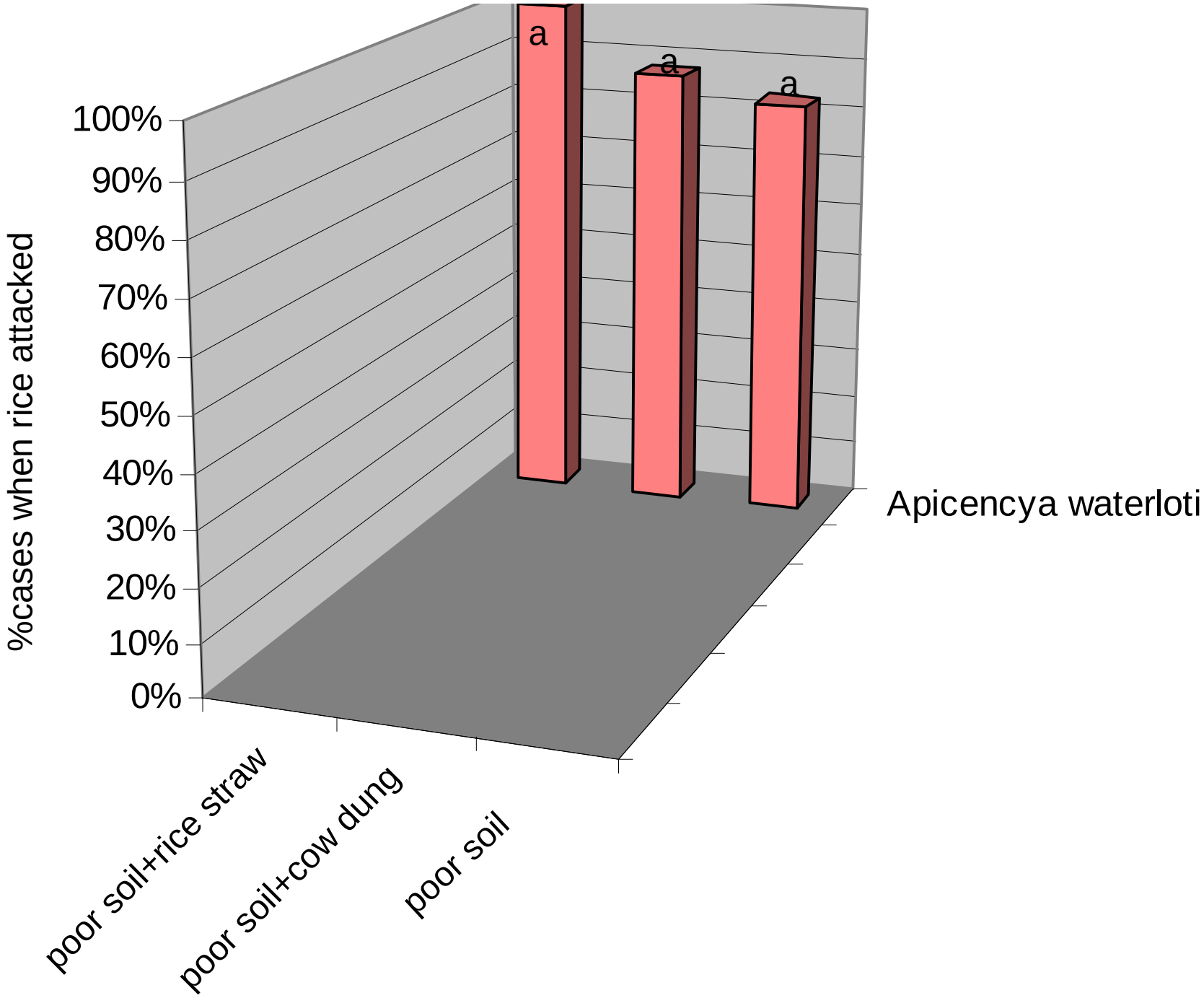


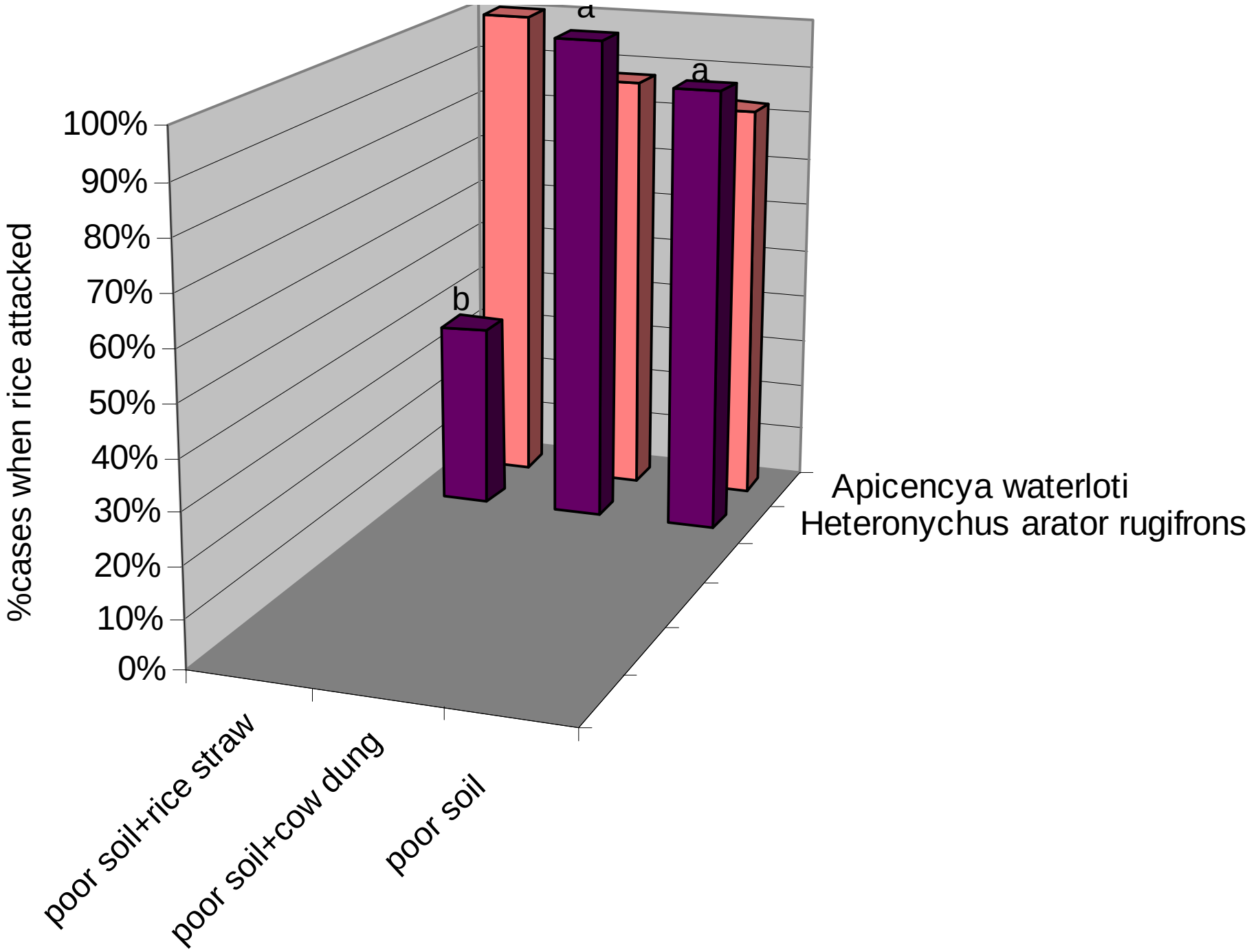




Objective: Minimizing Scarab beetle role as pests and optimizing their function as ecosystem engineers in multiple species-based Direct-seeding, Mulch-based Cropping (DMC) systems

Scarab beetle species
Apicencya waterlotii
Heteronychus arator rugifrons
Heteronychus bituberculatus
Heteroconus paradoxus
Heteronychus plebejus
Hexodon unicolor unicolor
Bricoptis variolosa


%cases when rice attacked
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
a
a
a
poor soil+rice straw
poor soil+cow dung
poor soil
Apicencya waterloti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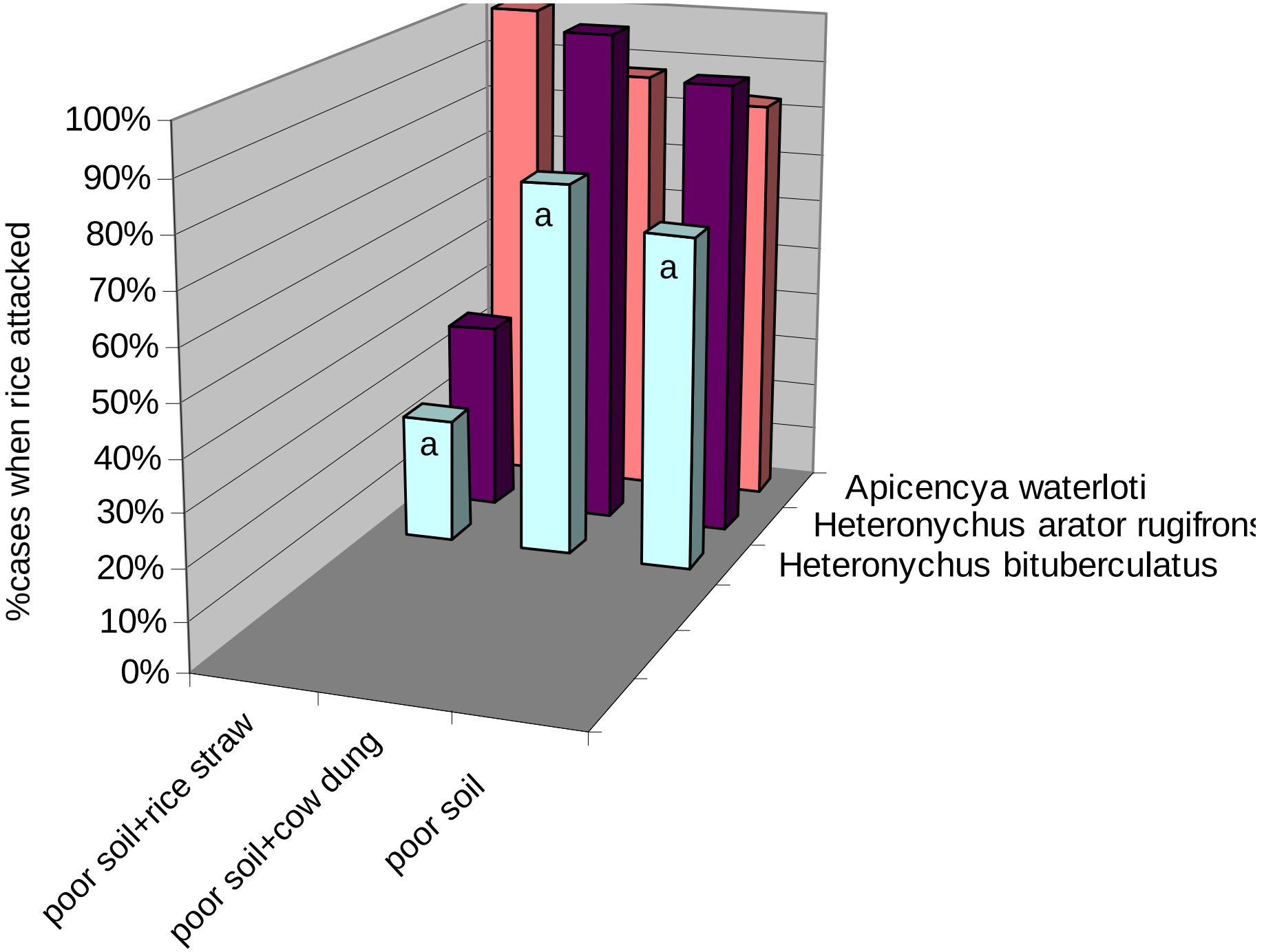
poor soil+rice straw
poor soil+cow dung
poor soil
Apicencya waterloti
Heteronychus arator rugifrons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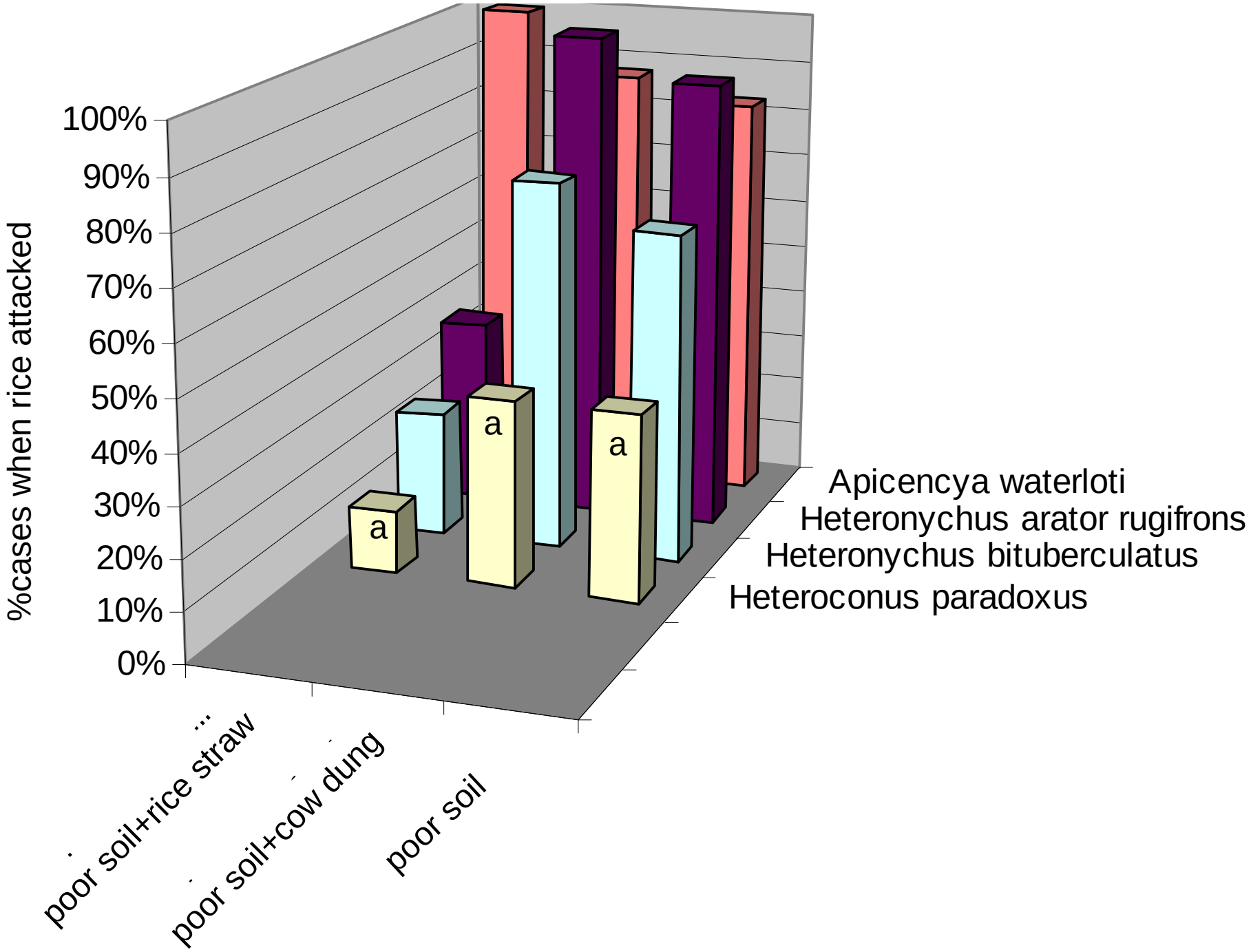
poor soil+rice straw
poor soil+cow dung
poor soil
Apicencya waterloti
Heteronychus arator rugifrons
Heteronychus bituberculatus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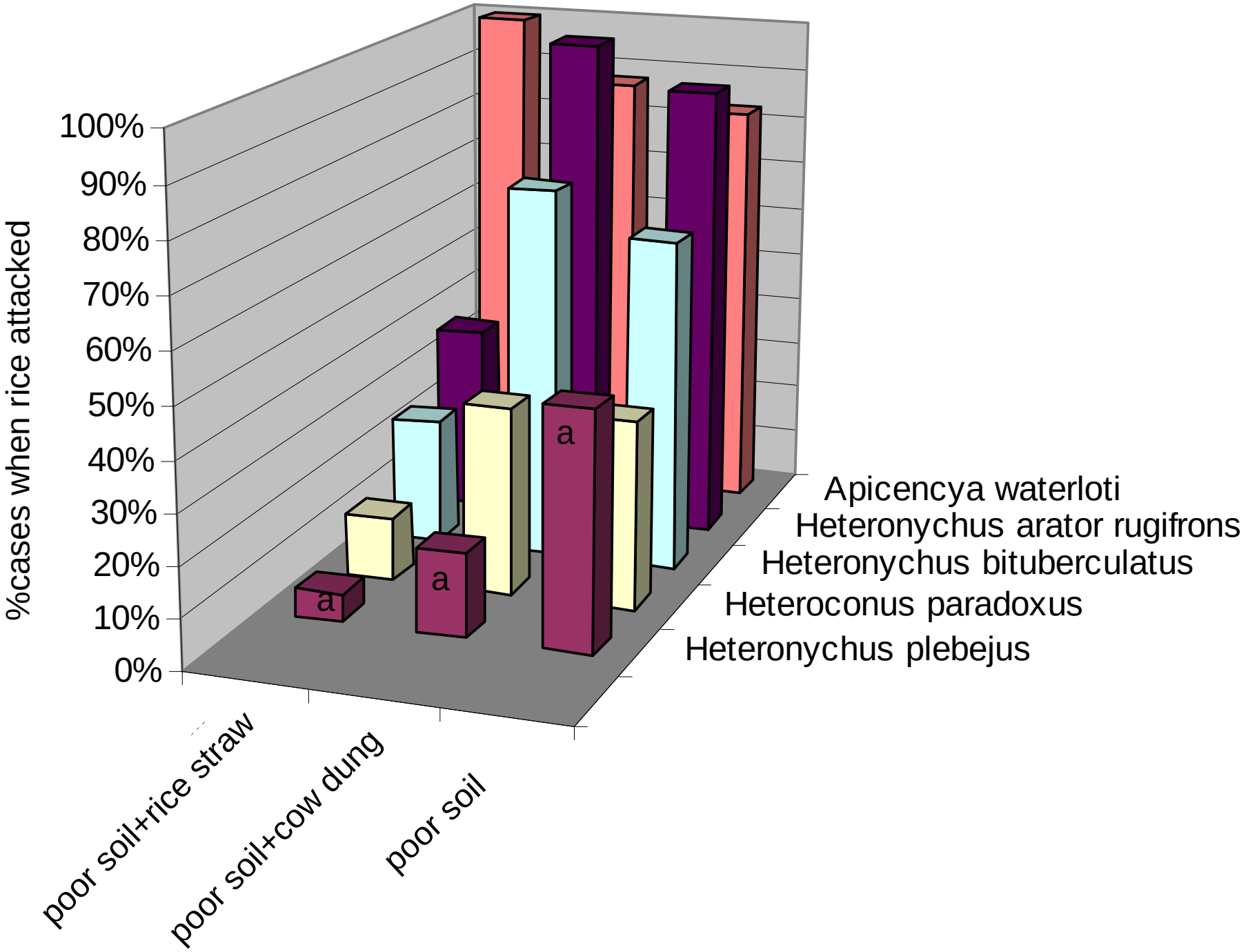
0%
a
a
a
Apicencya waterloti
Heteronychus arator rugifrons
Heteronychus bituberculatus
Heteroconus paradoxus
poor soil+rice straw
poor soil+cow dung
poor soil


%cases when rice attacked
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poor soil+rice straw
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Apicencya waterloti
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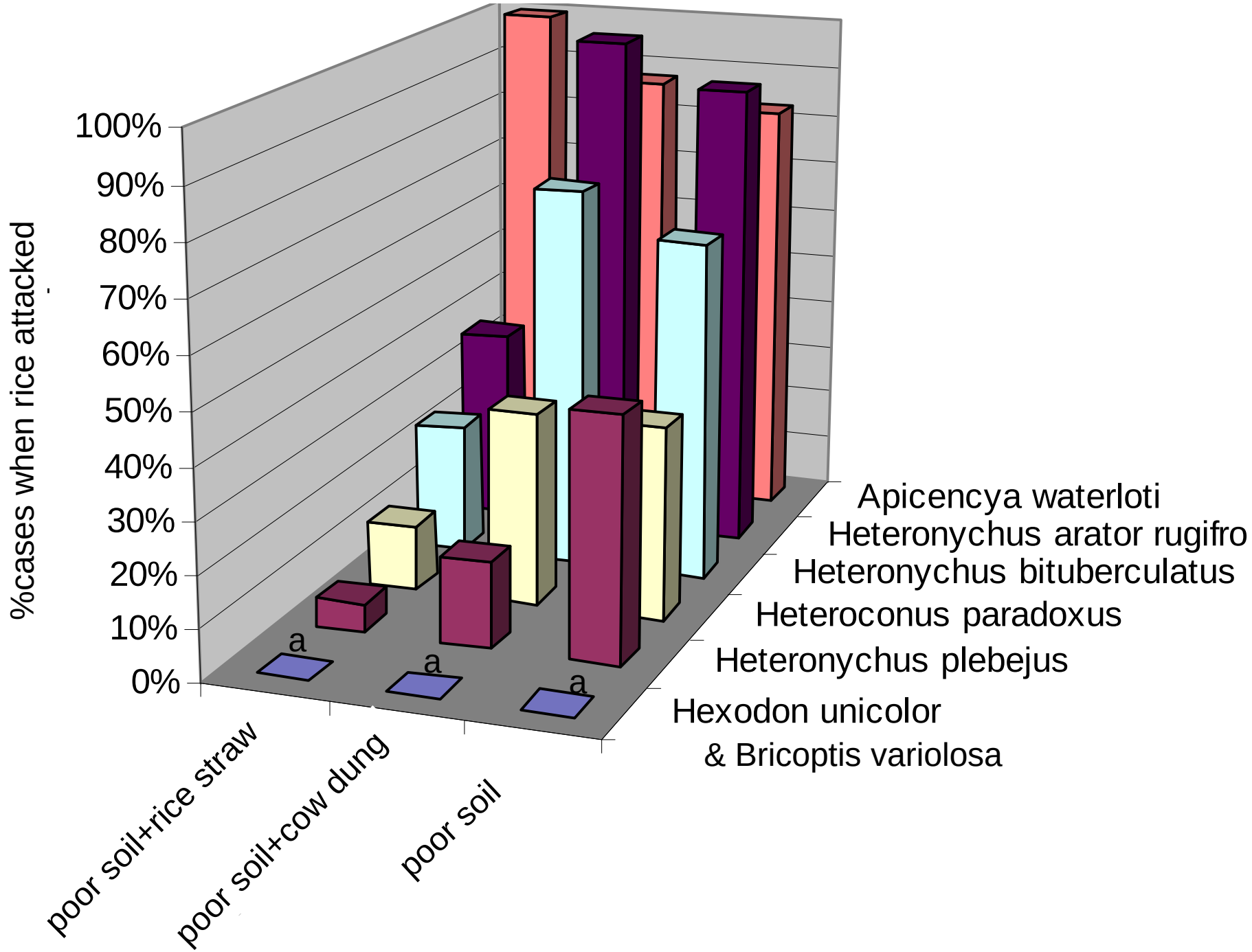
Heteronychus plebejus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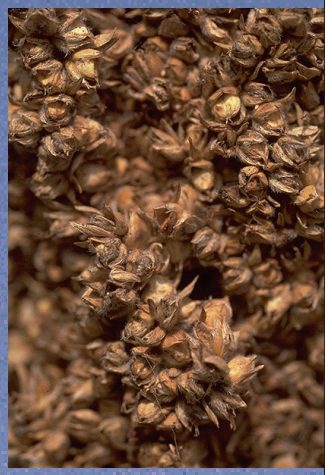
Heteroconus paradoxus
Heteronychus plebejus
Hexodon unicolor
& Bricoptis variolosa

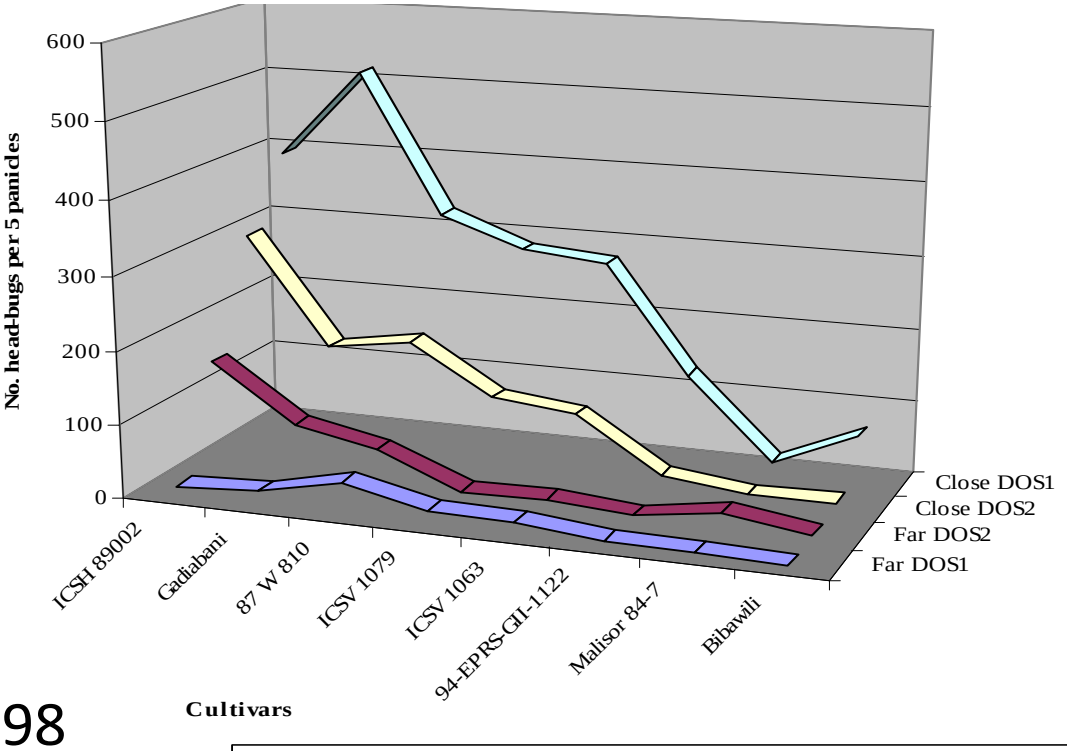
Sorghum panicle-feeding bugs in West and Central Africa

Eurystylus oldi

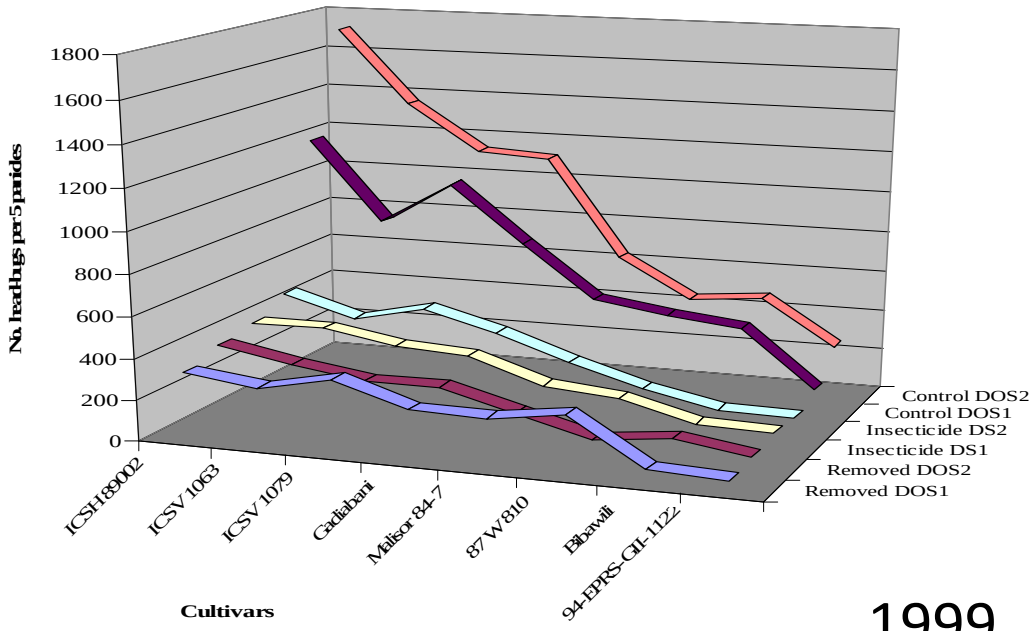


Management of plant bugs on castor bean to reduce sorghum infestation

- Studies conducted at the village level in 1998-99 in resp. 5 and 16 villages of the Kolokani region, Mali
- Split-plot designs with 3 factors: sorghum cv (8); date of sowing (2); and « castor treatment » (2-3):
  - 1998 : sorghum fields located in the vicinity vs remote from castor plants
  - 1999 : all sorghum fields located in the vicinity of castor, with management of castor spikes (insecticide spraying or spike manual removal) vs no treatment)


600
500
400
300
200
100
0
No. head-bugs per 5 panicles
ICSH 89002
Gadiabani
87 W 810
ICSV 1079
ICSV 1063
94-EPRS-GIL-1122
Malisor 84-7
Bibawili
Cultivars
Close DOS1
Close DOS2
Far DOS2
Far DOS1

1998


1800
1600
1400
1200
1000
800
600
400
200
0
No. head-bugs per 5 panicles
ICSH 89002
ICSV 1063
ICSV 1079
Gadiabani
Malisor 84-7
87 W 810
Bibawili
94-EPRS-GIL-1122
Cultivars
Control DOS2
Control DOS1
Insecticide DS2
Insecticide DS1
Removed DOS2
Removed DOS1

1999

Alternate hosts and life-cycle of Eurystylus oldi in Sudano-Sahelian West Africa

Rattle-box

Pigeon pea

Cotton

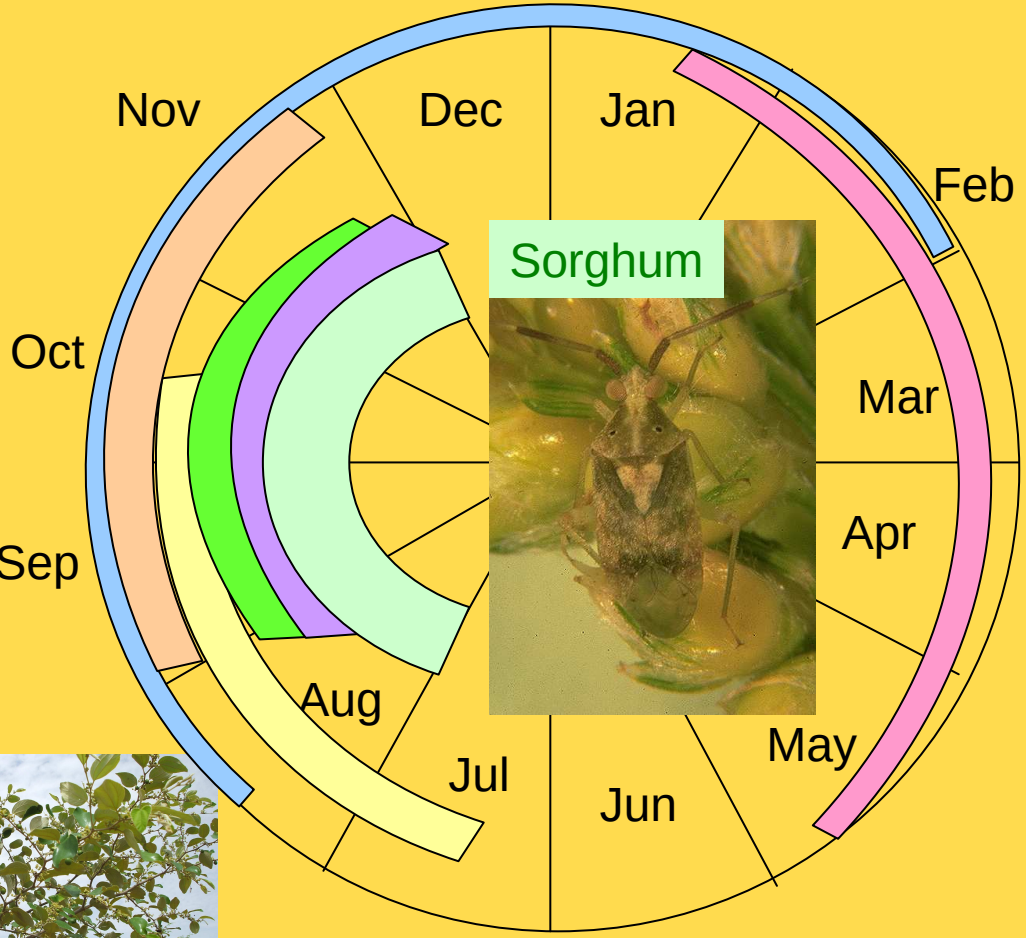
Sesbania

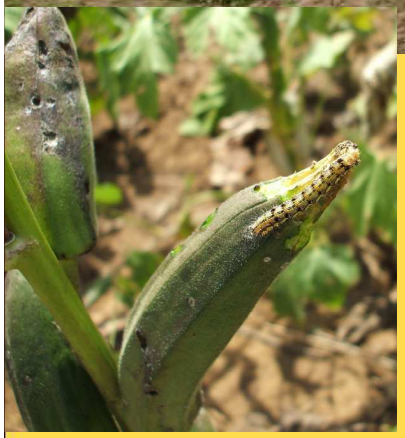
Jujube

Castor Bean

Mango

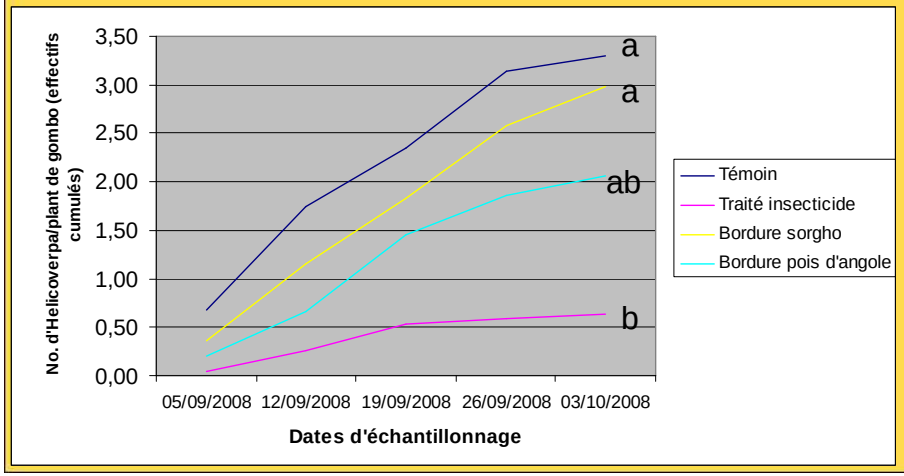
Spider plant

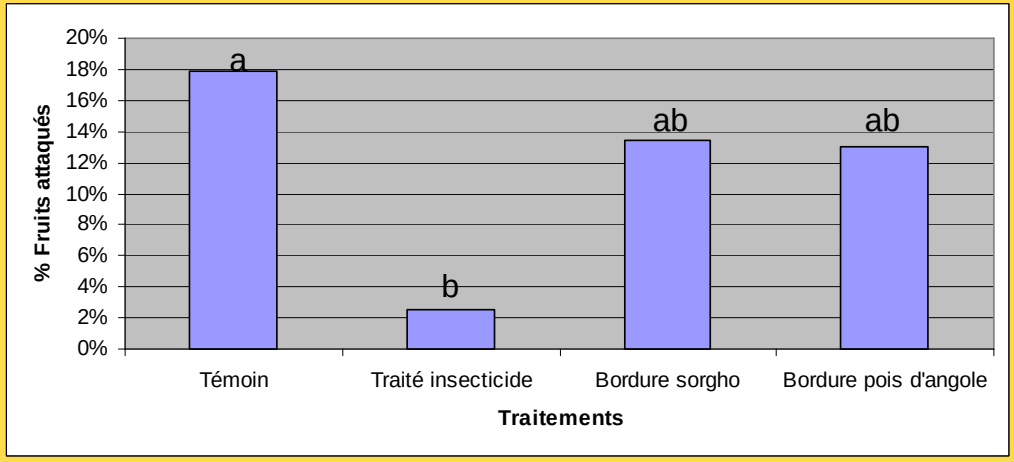




In Niger, in terms of trap cropping & conservation biological control potential for *Helicoverpa armigera* on okra:

- Pigeon Pea > Sorghum > Cotton





Pros and cons of three plant species tested in Niger as perimeter trap plants around okra fields for Tomato Fruit Worm (*Helicoverpa armigera*) control

Criteria \ Plant species	Pigeon Pea	Sorghum	Cotton
Attractiveness level	+	+/-	+/-
Attractiveness period duration	+	-	+
Ease of visual inspection and manual control	+	-	-
Conservation biological control effectiveness	-	+	-
Potential for “assisted” control	-	-	+
Effects against other pests	+/-	+	-

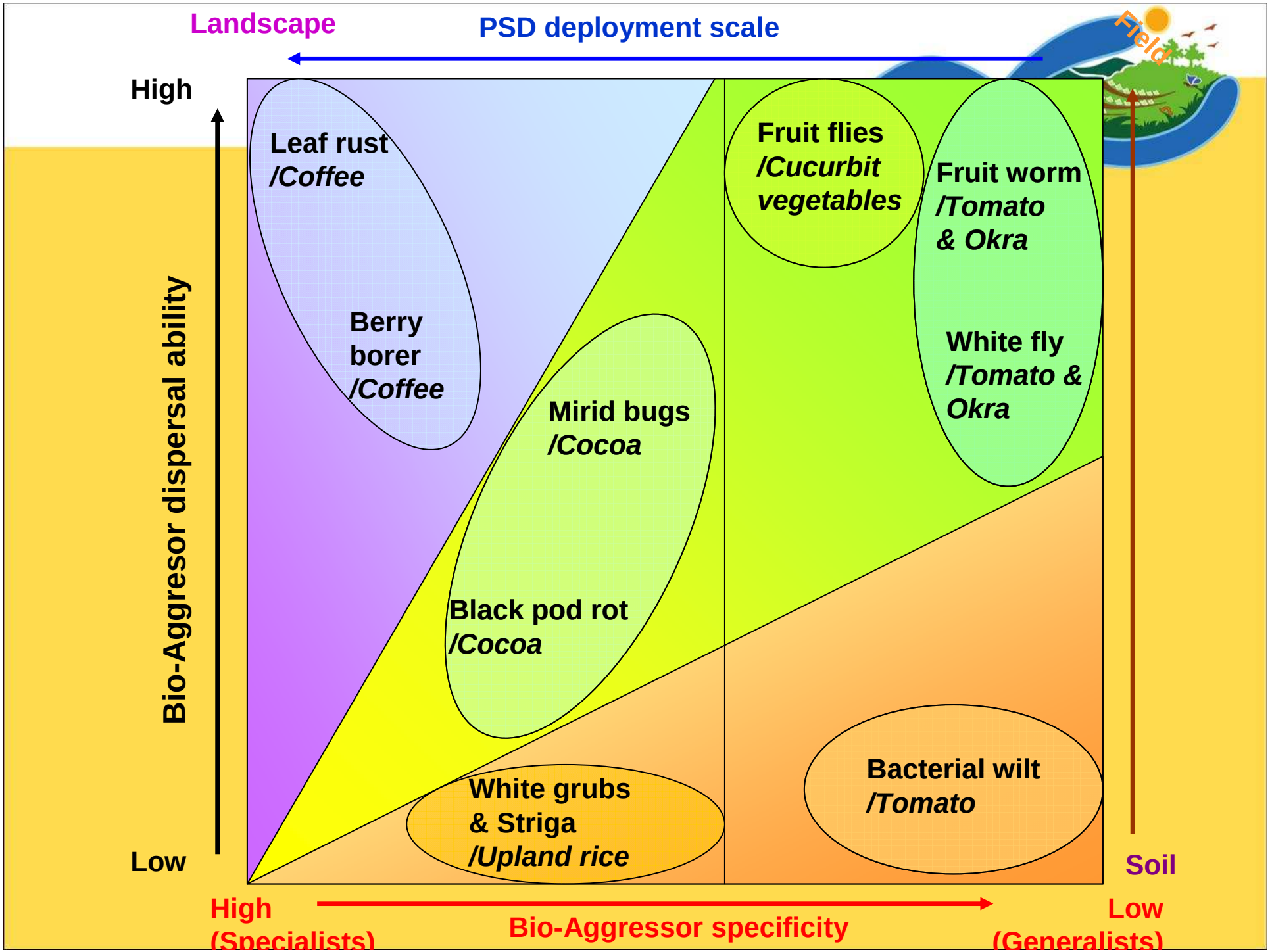
Importance taking into account upper scales

- Emerging adults of « plastic » white grubs species will damage neighbouring upland rice fields that are not managed in an agroecological manner
- In the case of trap-cropping (e.g. vs TFW on okra), or cycle-breaking strategies (e.g. panicle-feeding bugs on sorghum), if the alternate host used has no dead-end properties, care should be taken not to turn a « sink » for pests into a « source » of infestation at upper spatial and temporal scales
- At an even larger scale, dead-end trap plants that are both highly attractive for egg-laying by adult female pests and unfit for the development of their progeny, may also end up selecting pest populations that will overcome this suicidal egg-laying behaviour

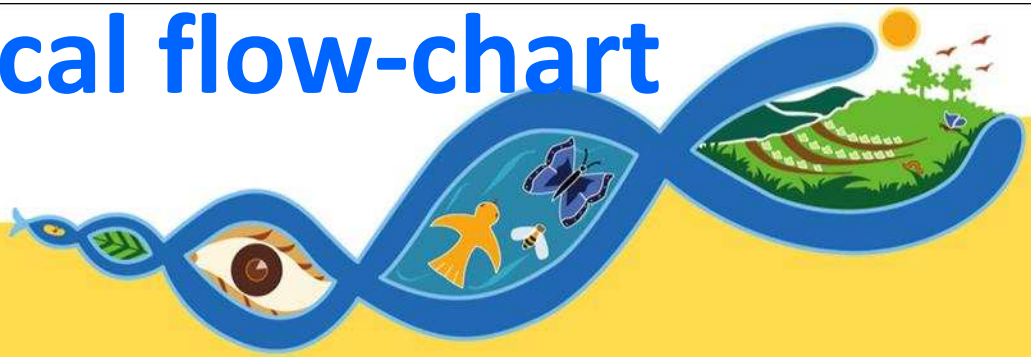
THE CIRAD OMEGA3 PROJECT'S APPROACH AND CASE STUDIES

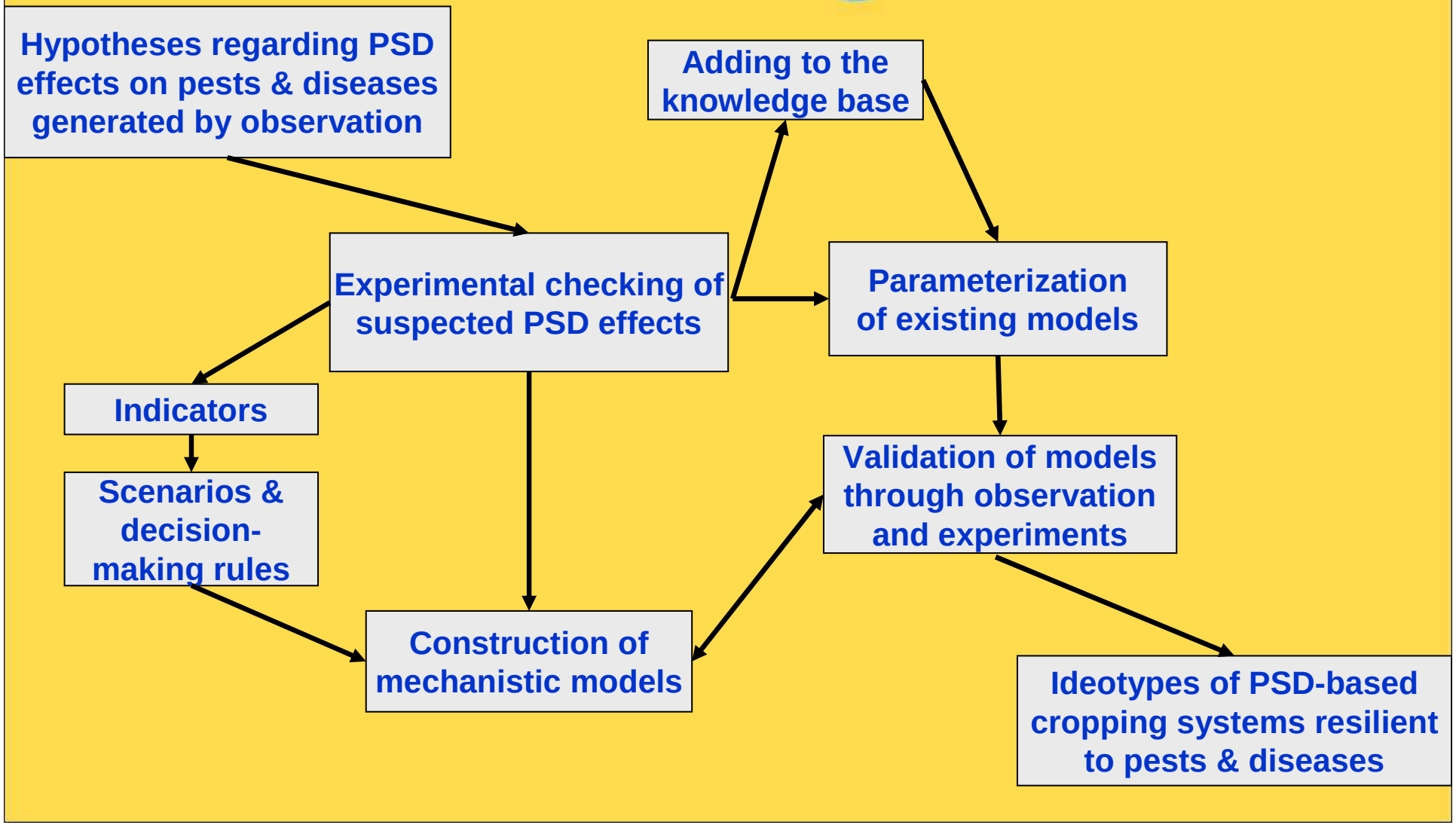
Optimisation des Mécanismes Écologiques de Gestion des bio-Agresseurs pour une Amélioration durable de la productivité des Agrosystèmes"

Ω3


Landscape
PSD deployment scale
Field
High
Low
Bio-Aggresor dispersal ability
Leaf rust /Coffee
Berry borer /Coffee
Fruit flies /Cucurbit vegetables
Fruit worm /Tomato & Okra
White fly /Tomato & Okra
Mirid bugs /Cocoa
Black pod rot /Cocoa
White grubs & Striga /Upland rice
Bacterial wilt /Tomato
Soil
High (Specialists)
Bio-Aggressor specificity
Low (Generalists)

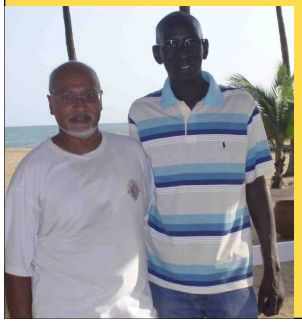
Ω³'s methodological flow-chart





Thanks to our partners:

- ICRISAT (Niger & Mali)
- ICRISAT, INRAN, University of Niamey (Niger)
- FOFIFA, University of Antananarivo & TAFA (Madagascar)
- Farmers



Session 3: The functional role of agrobiodiversity: from farms to landscapes

THE PEST AND DISEASE CONTROL FUNCTION OF AGROBIODIVERSITY AT THE FIELD SCALE

A. Ratnadass[1], J. Avelino[2], P. Fernandes[3], R. Habib[4] & P. Letourmy[5]
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2. Cirad - Controlling Pests and Diseases in Tree Crops research unit – IICA/PROMECAFE – San José – Costa Rica
3. Cirad - HortSys research unit – Pram – Le Lamentin - Martinique
4. Cirad – Persyst Scientific Department Director – Montpellier – France
5. Cirad – Annual Cropping systems research unit – Montpellier – France

Abstract - Among agrobiodiversity enhancement options, the planned introduction and management of plant species diversity (PSD) in agroecosystems is a promising way of breaking with "agrochemistry" and moving to "agroecology". Besides agronomic and economic benefits, PSD may reduce pest and disease impact via several causal pathways. We report on instances pest and disease regulation processes in tropical cropping systems, emphasizing the soil and field levels. We thus studied the influence of soil organic matter quantity and quality on the status of Scarab beetles associated with upland rice in Madagascar, in view of minimizing their role as pests and optimizing their function as ecosystem engineers in multiple species-based Direct-seeding, Mulch-based Cropping (DMC) systems. We also studied in West Africa the various host plants of sorghum panicle-feeding bugs, in order to manage these pests (and grain molds they transmit) via a combination of trap cropping and cycle rupture, and the potential of several trap crops for managing the tomato fruitworm (and in a subsidiary way the cotton white fly and the TYLC-transmitted disease) on okra. Although processes studied primarily operate at the field level, results obtained stress the need to take into account larger scales, both spatial and temporal. This approach is developed in the Cirad Omega3 project which builds on tropical case studies, representing a broad range of PSD scales and deployment modalities (soil, field, landscape, and DMC, horticultural and agroforestry systems), according to a typology of pests and pathogens based on life-history traits the most amenable to manipulation by PSD (specificity and dispersal ability). Further to results aiming at immediate impact, more generic results are expected, after formalizing the ecological processes studied, namely decision-making rules which will help set up models to predict the impact of PSD on pests and pathogens with similar life-history traits.